The effect of structured reflection on the diagnostic accuracy of postgraduate trainees during real patient encounters

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DECLARATION

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ABSTRACT

Context

Structured reflection has been shown to improve the diagnostic competence of undergraduate and postgraduate trainees in a range of experimental settings using written case scenarios. Evidence supporting the use of this strategy during real patient encounters is lacking. This paper reports on a study conducted to determine the effects of structured reflection on the diagnostic accuracy of postgraduate medical trainees during bedside tutorials using real patient encounters.

Method

Fifty-five postgraduate trainees in Internal Medicine at the University of Cape Town, South Africa, were prospectively studied during 18 beside tutorials using real patient encounters. Each patient encounter was conducted as a 4-stage diagnostic process and a diagnostic accuracy score (DAS) was calculated for all participants at each stage:

- DAS 1: immediately upon arrival at the patient's bedside (visual cues only);
- DAS 2: after an oral presentation of the interview and physical examination findings (pre-reflection);
- DAS 3: after review of the clinical data using a process of structured reflection (post-reflection);
- DAS 4: after discussion of the patient facilitated by the attending physician (facilitated reflection).

Memory structure and flexibility in thinking of participants were evaluated using the Diagnostic Thinking Inventory (DTI) and compared to their post-reflection diagnostic accuracy scores.

Results

A total of 212 diagnostic events were studied. Friedman's test demonstrated a significant difference when comparing the median diagnostic accuracy scores (DAS) of the respective stages of the diagnostic process (χ^2 (3) = 406.34, p value < 0.001).

The Wilcoxon signed-rank test confirmed that there was a significant difference between the immediate DAS (DAS 1) and the pre-reflection DAS (DAS 2) ($Z = 8.66$, p value < 0.001), the pre-reflection DAS (DAS 2) and the post reflection DAS (DAS 3) ($Z = 4.98$, p value < 0.001). Linear regression identified a significant relationship between DTI scores and DAS 3 (p value $= 0.035$), however this explains only a small portion of the variation in the data ($r^2 = 0.093$).

Conclusion

Structured reflection improved the diagnostic accuracy of postgraduate trainees during real patient encounters at the bedside. These data provide support for the suggestion that clinical teachers should consider adding structured reflection to their toolbox of bedside teaching strategies. In addition, DTI scores may help clinical teachers identify trainees struggling with the development of diagnostic expertise.

ABBREVIATIONS

DTI	-	Diagnostic Thinking Inventory
PMPs	-	Patient management problems
SCTs	-	Script concordance tests
CRPs	-	Clinical reasoning problems
SSA	-	sub-Saharan Africa
UCT	-	University of Cape Town
HREC	-	Human research ethics committee
DAS 1	-	Diagnostic Accuracy Score 1
DAS 2	-	Diagnostic Accuracy Score 2
DAS 3	-	Diagnostic Accuracy Score 3
DAS 4	-	Diagnostic Accuracy Score 4
TB	-	Tuberculosis
HIV	-	Human Immunodeficiency Virus
IgA	-	Immunoglobulin-A
SLE	-	Systemic lupus erythematosus
MRI	-	Magnetic resonance imaging
CT	-	Computed tomography
IQR	-	Interquartile range
n	-	Number of participants
OSCE	-	Objective structured clinical examination

TABLE OF CONTENTS

DECLARATION ii

ABSTRACT iii

ABBREVIATIONS v

LIST OF FIGURES ix

LIST OF TABLES ix

CHAPTER ONE

LITERATURE REVIEW

1.1 INTRODUCTION 1

1.2 REQUIREMENTS OF THE DIAGNOSTIC THINKING PROCESS 1

1.3 BIOMEDICAL KNOWLEDGE AND EXPERTISE 2

1.4 COGNITION AND EXPERTISE 3

1.5 CRITICAL REFLECTION 4

1.6 COGNITIVE PROCESSES USED TO MAKE A DIAGNOSIS 5

1.6.1 Hypothetico-deductive model 5

1.6.2 Dual Processing 5

1.7 ‘TYPE 1’ VERSUS ‘TYPE 2’ REASONING 6

1.8 UNDERSTANDING CLINICAL REASONING ERRORS 7

1.9 STRATEGIES THAT SUPPORT DIAGNOSTIC THINKING PROCESSES 8

1.9.1 Structured reflection to enhance diagnostic accuracy 8

1.9.2 Role of the teacher 10

1.10 EVALUATION OF DIAGNOSTIC THINKING PROCESSES 10

1.10.1 Diagnostic accuracy 10

1.10.2 Cognition 11

1.11 CONCLUSION 12

1.12 REFERENCES 13

CHAPTER TWO

THE EFFECT OF STRUCTURED REFLECTION ON THE DIAGNOSTIC ACCURACY OF POSTGRADUATE TRAINEES DURING REAL PATIENT ENCOUNTERS

2.1 INTRODUCTION 20

2.2 METHODS 22

2.2.1 Participants 22

2.2.2 Study design 22

2.3 PROCEDURE 22

2.3.1 Case Selection 23

2.3.2 Case Tutorial 24

2.4 DATA ANALYSIS 26

2.5 RESULTS 27

2.5.1 Participants 27

2.5.2 Diagnostic Events 27

2.5.3 Analysis 30

2.6 DIAGNOSTIC THINKING INVENTORY 31

2.7 DISCUSSION 33

2.8 CONCLUSION 36

2.9 REFERENCES 37

APPENDIX A: The Diagnostic Thinking Inventory developed by Bordage, Grant and Marsden [31] 42

APPENDIX B: University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC) Reference: 762/2013 47

APPENDIX C: Structured Reflection Chart – example for shortness of breath 48

APPENDIX D: Notice of Intention to submit Master's Dissertation for Examination 49
APPENDIX E: Approval of Study Proposal 51
APPENDIX F: Supervisor appointment form 52
APPENDIX G: Author Instructions 53

LIST OF FIGURES

Figure 1.1: Essential building blocks of the diagnostic reasoning process 2

Figure 1.2: Multidimensional nature of reflective thinking 9

Figure 2.1: Research method outline 24

Figure 2.2: Comparison of Diagnostic accuracy scores (DAS) 31

Figure 2.3: Comparison of the Diagnostic Thinking Inventory (DTI) 32

Figure 2.4: Relationship between DAS 3 and DTI scores 33

LIST OF TABLES

Table 2.1: Diagnostic accuracy scoring system.. 26

Table 2.2: Clinical case, presenting problem and preferred working diagnosis........ 28

Table 2.3: Diagnostic accuracy scores at each stage of the diagnostic process...... 30

CHAPTER ONE

LITERATURE REVIEW

1.1 INTRODUCTION

Clinical reasoning is a multifaceted, cognitive process health care practitioners use to evaluate a patient's medical problem(s), formulate a working clinical diagnosis and develop an appropriate management plan.[1] The diagnostic thinking process, a term coined by Grant, née Gale, in the early 1980s,[2] requires careful consideration of each piece of information obtained during the patient consultation, to determine the most plausible explanation(s) for the presenting problem(s).[3] This process is central to the provision of efficient, safe patient care.[4,5]

More than four decades of research has been dedicated to unravelling the diagnostic reasoning process.[3,6] This complex skill, the sum of thinking and decision-making, gains an inherent mystique owing to the fact that each patient consultation is a unique combination of multiple, case-specific variables. A sound foundation of biomedical knowledge, derived from both theory and practical experience, together with the learned skill of systematically processing clinical data, enable expert clinicians to select out the 'high predictive value' information required to make a correct diagnosis.[7] The reflective ability of expert clinicians has recently been identified as an additional metaskill required to enhance the clinician's diagnostic reasoning potential.[8] Expert diagnosticians, who make these complex decisions effortlessly, 'showcase' the gold standard of clinical reasoning.[5]

1.2 REQUIREMENTS OF THE DIAGNOSTIC THINKING PROCESS

Sternberg and Horvath succinctly framed the essential building blocks of the diagnostic reasoning process as three features that characterize the practice of experts in real world settings. These three attributes enable experts to redefine a problem in accordance with their experience and move forward to solve it more efficiently.[9] (Figure 1.1)

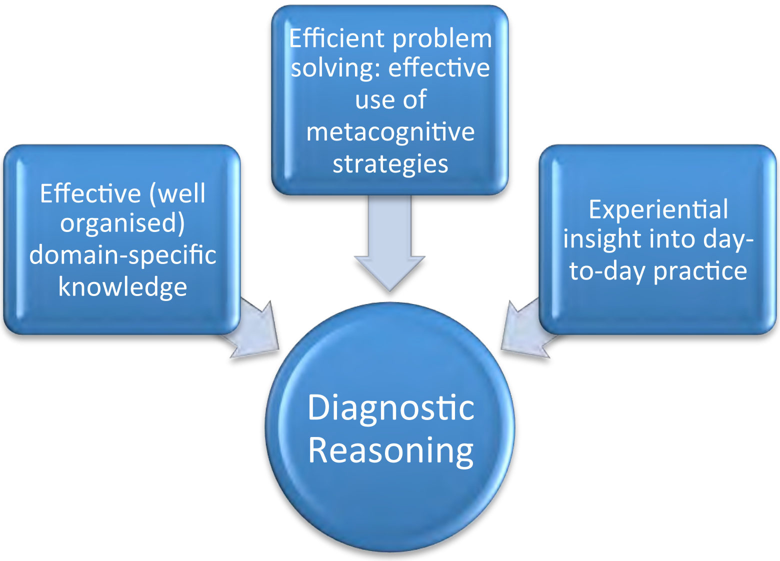

Figure 1.1: Essential building blocks of the diagnostic reasoning process

Knowing more about the basic building blocks of the diagnostic process is critical for clinician educators tasked with the responsibility of educating health care professionals.[5] Furthermore, while the process of becoming an expert follows a continuum of experiential learning, an understanding of the subconsciously attained attributes attached to knowledge structures and problem-solving skills can also be used to mediate improvements in the diagnostic competence of clinical trainees.[10]

So, given the key contributions that biomedical knowledge, memory structures and reflection on experience make to the conversation about clinical reasoning, each are briefly discussed in this section of the literature review.

1.3 BIOMEDICAL KNOWLEDGE AND EXPERTISE

Biomedical knowledge, the scientific foundation of clinical reasoning, is made up of basic sciences, clinical knowledge and experiential learning.[11] While the specific role of basic sciences knowledge in the diagnostic reasoning process has only been determined here recently,[10-14] the importance of the integration of these subsets of information, to develop a coherent knowledge structure that supports all the cognitive aspects of medical practice, has been appreciated for more than four decades.[15]

Two major advances, with regard to the role of biomedical knowledge in the process of making a diagnosis, have been instrumental in moving this field of health sciences education forward. First, the work by Feltovich and Barrows introduced the concept of cognitive frameworks that allow experts to deal expediently with the usual variations of a particular illness.[16,17] This led to the introduction of the term 'illness script' by Boshuizen and Schmidt in 1992.[10] This term describes the mental representation acquired by experienced clinicians that organizes the biomedical knowledge they use to make diagnoses into customized 'bytes', which enables them to rapidly make diagnoses of illnesses previously encountered. So, illness scripts, which arise from repeated experiences within real world events, are about what is expected, what acceptable variations of an illness are and how these variations relate to one another.[17]

Second, our understanding of the 'packing' of essential biomedical knowledge has been further enhanced by the recognition that experts, early on during a clinical encounter, identify key features of the clinical presentation that facilitate the rapid and efficient retrieval of these 'bytes' of essential knowledge needed to make a diagnosis and institute an effective management plan.[18,19]

Based on the preceding discussion it is clear that a key fundamental difference between experts and novices, with regard to biomedical knowledge, is that novices store and use biomedical knowledge in a haphazard way that initially does not facilitate the diagnostic process.[20] Experts, on the other hand, have customized, well-organized, easily retrievable encapsulated knowledge, which translates into the ability to rapidly and efficiently solve routine clinical problems.[5] This, combined with experience and the ability to critically reflect upon one's professional practice (discussed later), underpins the accuracy characteristic of the diagnoses made by expert diagnosticians.[21]

1.4 COGNITION AND EXPERTISE

The knowledge structures and cognitive processes that underpin human performance are critically important to the process of making a diagnosis.[22] Both performance and learning are functions of domain-specific knowledge and successful medical decision-making relies on both the efficient use of this information as well as productive problem-solving strategies.[22,23]

The critical role of knowledge structures in diagnostic thinking was first appreciated in the early 1970s when Ausubel and colleagues wrote that 'it [structuring] plays a key note in problem solving and involves a reorganization of the residue of past experiences so as to fit the particular requirement of the current situation'.[24] This was followed by the work of Janet Grant, née Gale, in which she focused on the key role memory structures play in the diagnostic reasoning process by exploring the 'structuring' and 'extrapolation' of information already organized in memory.[2] This work lead to the development of a Diagnostic Thinking Inventory (DTI), a self-administered instrument designed to provide insight into the changes in memory structure and flexibility of thinking.[25] The DTI is discussed in more detail later in this review

While human cognition is constrained by the limits of working memory (the system responsible for processing new and previously stored information),[22] the comprehensive, well organized and densely interconnected knowledge base of expert clinicians allows them to circumvent some of these limitations.[26] Indeed, the more frequently knowledge is used, referred to as 'deliberate practise', the smoother, more efficient and automated the observed performance of experts becomes.[27] Intermediate learners have lots of knowledge in place but lack the extensive connectedness displayed by experts, and novices have a sparse knowledge base with few connections.[22] These limitations curb the ability of junior trainees to efficiently and effectively conduct cognitive searches required to make a clinical diagnosis.

1.5 CRITICAL REFLECTION

When approaching clinical problems the hallmark of experts is that they largely make diagnoses using pattern recognition and illness script comparison strategies.[27,28] However, when the problem is not familiar, they spend more time and effort on reframing the clinical problem until the unusual or atypical presentation is recognized, using supportive problem-solving methods to arrive at a diagnosis.[29] In this setting, the patient interview is more thorough and directed, the physical examination is more comprehensive and investigations are used more liberally to support or refute the hypothesis(es) at hand.[30] There is a psychological shift, such that an openness to recognize and accept difficulties becomes the nature of the task, and ultimately, an environment in which the problem can be better understood, is fostered.[7,31] This defines the reflective practitioner whereby, under these circumstances, reflective skills allow the practitioner to set up and follow a systematic plan to address potential alternative diagnoses.[32] This strategy results in a broader base of hypotheses from which solutions can be drawn and renders the practitioner more mindful and attentive to discrepancies in supporting data.

Having highlighted the essential roles of biomedical knowledge, cognition and reflection in the diagnostic process, the ways in which these building blocks are used to make a clinical diagnosis are described in the next section of this literature review.

1.6 COGNITIVE PROCESSES USED TO MAKE A DIAGNOSIS

1.6.1 Hypothetico-deductive model

The earliest formulation of diagnostic reasoning and problem solving described the process as one of hypothesis generation and testing.[33] The clinician generated a limited number of hypotheses using the information at hand and each hypothesis, together with its likelihood of occurrence, was used to guide the collection of further clinical information to support or refute the hypotheses under consideration. In this model, clinicians actively sought clues with positive or negative predictive value, and, as each hypothesis was addressed and supporting evidence provided, the quality and specificity of the hypothesis improved. It became evident that experienced physicians generated better hypotheses more rapidly than novice clinicians who often had difficulty moving beyond the collection of necessary data and struggled to synthesize a diagnosis.[34]

1.6.2 Dual Processing

In the early 1990s, the dual process theory, stemming largely from the work done by Epstein and Hammond, emerged as a more comprehensive model of diagnostic thinking.[35,36] This theory describes two cognitive systems that are jointly involved in the process of making a diagnosis.

Type 1 reasoning is an ‘intuitive system’ of hypothesis generation commonly described as a ‘gut feeling’. It is a reflex and rapid cognitive response to a familiar clinical problem.[37] Readily available contextual information cues the immediate recognition of typical illness configurations known as illness scripts, which generates automated hypotheses.[35]

Work done by Gale, which looked at the initiation of the diagnostic reasoning process, showed that the process of problem solving starts as soon as the first piece of clinical information is elicited. Immediate cues, even from a single piece of information, can be interpreted from extrapolated memorized content.[2,38]

Verbal cues and visual information, regarding a patient's suspected problem, are non-redundant. When reviewed, each has a significant, absolute impact on the assessment of disease probability, and the identification of visual (non-verbal) information is a highly influential subset skill in the reasoning process.[39] Previous work has documented that if an expert takes into consideration the correct diagnosis during the first five minutes of a consultation, this hypothesis becomes definite in ninety-five percent of the cases.[40]

The second cognitive process, Type 2 reasoning, is an 'analytical' system involving the deliberate sorting of information used to generate likely hypotheses.[35] While this process, which relies on rational judgment, shares similarities with the earlier hypothetic-deductive model of hypothesis generation and testing, it places an increased emphasis on the reflective skills of the clinician.[34]

Constructing multiple hypotheses about a clinical problem, and reflecting on the validity and implications of each of these, as described by Dewey in 1933, creates an enriched understanding of the problem, which leads to an efficient and thoughtful approach to solving it.[41] Encapsulated knowledge, which evolves from this behaviour, enhances the quality of the illness scripts, highlighting a relationship that in future allows for exemplars of the problem to be approached using a more intuitive diagnostic reasoning process.[32,42]

1.7 'TYPE 1' VERSUS 'TYPE 2' REASONING

Type 1 and Type 2 processing strategies are jointly involved throughout the process of making a diagnosis.[43] The order in which clinicians proceed when solving diagnostic problems is, however, variable. While the specific context in which one system predominates over the other remains unclear,[44] it is accepted that experienced physicians use ‘intuition’ to solve simple, uncomplicated, day-to-day problems.[45] Type 2 reasoning, an analytical approach, is favoured when the outcome stakes are high, the situation is complex and ill-defined, or if there is an air of uncertainty in the way the problem is structured.[43,46] The reasoning process is not always as clear-cut as this and real problems, which are always multifactorial, are solved with an approach that includes both Type 1 and Type 2 cognitive processes.[47]

1.8 UNDERSTANDING CLINICAL REASONING ERRORS

Based on our current understanding of clinical reasoning, it should be possible to determine and remediate biases in the cognitive processes that result in diagnostic errors. Addressing system-related diagnostic errors could bring about significant improvements in diagnostic accuracy and patient care.[48]

Diagnostic errors occur in about fifteen percent of patient encounters.[49] Whilst it seems reasonable to postulate that most errors in clinical decision making are largely due to gaps in the medical knowledge of practicing clinicians, the majority of errors that do occur, at least in part, result from individual doctor cognitive processing biases rather that knowledge gaps.

The educational literature has identified cognitive errors as one of the greatest challenges that need to be addressed to reduce the morbidity and mortality associated with clinical error.[48] Furthermore, it is essential that these errors are understood and addressed in the context of the clinical reasoning process to ensure that educational strategies continue to focus on ways of improving the diagnostic accuracy of both students and doctors alike.

The literature remains divided on which system of thinking encourages more bias. The cognitive forcing strategies associated with Type 2 processing may be thought of as being preventative by limiting the use of pattern recognition pathways that can lead to error. However, it has been shown that conscious, deliberated, slow reasoning in novices’ results in poorer performance.[21] While these studies provide useful information, it should be remembered that research of this nature focuses on the rudimentary analytical processing ability of novices and not the cognitive processing skills of experienced experts.

It is worth noting that slowing down and increasing attention to analytical thinking are insufficient to increase diagnostic accuracy,[44] even though this is a fundamental rule of human performance. So, regardless of the type of reasoning employed, none will improve accuracy if the fundamental requirements of diagnostic thinking, including high-quality foundation knowledge, are not met.[50]

It therefore makes sense that Norman and Eva, doyens in the world of medical education, concluded in their review entitled 'Diagnostic error and clinical reasoning', that diagnostic error cannot be ascribed to a particular type of cognitive processing since each problem addressed by the clinician requires a different interaction of both types of cognitive processes. They proposed, "Errors are likely to result from an interaction between knowledge deficits and processing problems, not from one or the other."[6]

1.9 STRATEGIES THAT SUPPORT DIAGNOSTIC THINKING PROCESSES

Rapid advances in biomedical knowledge are producing an ever-increasing volume of 'must know' information. This, together with a shift from didactic, lecture-based teaching, thought to encourage passive, rote learning, is driving the increasing interest in learning strategies that may help students organize, store, integrate and recall information more effectively and efficiently.[51, 52]

There is ongoing interest in learning methods based on the hypothesis that meaningful learning occurs when new information is assimilated within existing frameworks.[24] So, strategies aimed at improving the quality of mental frameworks of trainees have been introduced.[53]

1.9.1 Structured reflection to enhance diagnostic accuracy

Pioneers in the field of reflective practice in medicine, Mamede and Schmidt have explored the behaviours and reasoning processes of primary health care doctors when dealing with complex and unusual clinical problems.[29,42,54] Initial research provided empirical evidence for the development of a theoretical model describing the multidimensional nature of reflective thinking. This model describes five sets of behaviours, attitudes and reasoning processes, which are used when addressing complex clinical tasks.[32] (Figure 1.2)

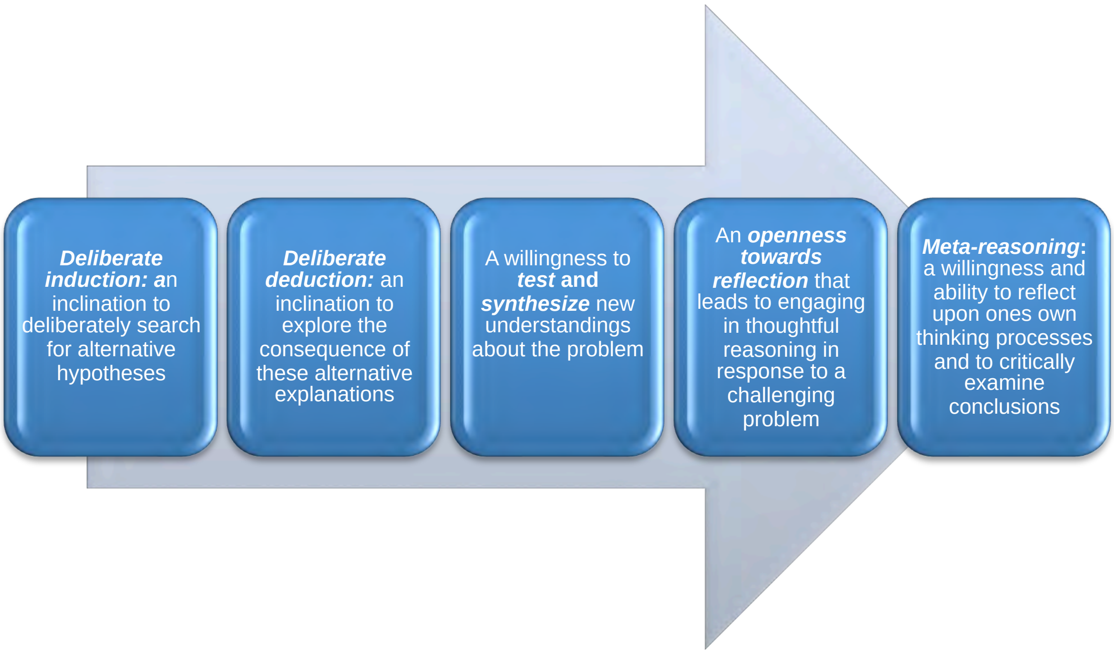

Figure 1.2: Multidimensional nature of reflective thinking

This empiric structure gave Mamede a framework to explore the impact of a process of structured reflection on the diagnostic accuracy of novice learners.[28,32,42] Participants were asked to provide a list of hypotheses for a 'paper-case' problem, and then record the findings, which did, or did not, support their diagnostic options. Structured reflection, using these 'paper-cases' appeared to enhance the learning of clinical knowledge and was therefore deemed to be an effective instructional approach to developing diagnostic competence in students.[42] Further work showed that reflection, performed by postgraduate medical residents, also generated more accurate hypotheses, and that this effect was more pronounced in complex medical cases.[28]

In this work it was also found that non-analytical reasoning methods, such as pattern recognition, were as effective as reflective reasoning for diagnosing routine clinical cases. It wasn't until participants were exposed to clinical situations of uncertainty and uniqueness that the value of reflection as a tool to improve diagnostic accuracy became evident.[28] Findings also provided support for the hypothesis that reflection helped to foster the acquisition and maintenance of diagnostic expertise.[27,28] Mamede and colleagues have suggested that reflection not only enriches the mental representation of diseases, but also influences representation-related, but different diseases.[54]

1.9.2 Role of the teacher

Because of the paucity of scientific evidence regarding optimal learning strategies, many teaching approaches are based largely on expert opinion.[55] Strategies are aimed at encouraging teachers to facilitate learning instead of trying to impart knowledge.[56] This is best done in a context where the application of new knowledge, to real life situations, prevails.[57,58]

Case exemplars should therefore 'not be synthesized but instead be genuine, ensuring that the actual uncertainties, inconsistencies, imperfections, complexities and ambiguities of the clinical data are encompassed'.[58] A teacher functions best when he or she is unfamiliar with the case exemplar because this forces them to demonstrate the process of clinical reasoning.[55]

Keeping in mind the role of critical knowledge in the diagnostic process, an introduction to clinical reasoning needs to be initiated when students, who have a willingness to question, learn and compare information, are well grounded in core science knowledge. This will offer the stable foundation on which clinical reasoning frameworks can be constructed.

1.10 EVALUATION OF DIAGNOSTIC THINKING PROCESSES

There are two aspects of the diagnostic thinking process for which measurement instruments have been developed. This section of the literature review provides a summary of instruments used for both purposes.

1.10.1 Diagnostic accuracy

Diagnostic accuracy is the ability to use clinical information, obtained during a patient encounter, to make a correct diagnosis. To date, the routine use of valid, reliable and time efficient methods to determine the diagnostic accuracy of medical trainees remains a challenge.[59] Based on an early assumption that clinical problem solving is a generic ability, the earliest form of testing relied on the use of patient management problems (PMPs).[60] This strategy, which asked students to respond to problems that were presented in a standardized format, soon became a widely accepted measure of clinical judgment.[61] By the end of 1970 it was clear that PMPs, although having useful attributes, were dogged by psychometric inadequacies,[62] and other assessment strategies (described below) were developed to replace PMPs.[63]

Script Concordance Tests (SCTs)[64] and Clinical Reasoning Problems (CRPs)[65] were later developed to evaluate one or more aspects of the clinical reasoning process through questions directed at clinical scenarios. Both methods have been used in a variety of contexts and are recognized as useful ways of assessing the clinical reasoning skills of medical trainees.[64,66] SCTs are a practical, valid and time efficient method of testing clinical reasoning in cases of clinical uncertainty,[67] while CRPs provide a more comprehensive picture by evaluating the ability of trainees to synthesize clinical data and generate diagnostic hypotheses. When combined, these two instruments provide a comprehensive assessment of clinical reasoning, but the utility of this approach is limited by the time required to perform such a thorough assessment.[65]

1.10.2 Cognition

Cognition, the memory structures and processes used to store and retrieve pre-existing knowledge is an essential prerequisite for the diagnostic thinking process.[38] In the process of unravelling the nature of memory structures clinicians use to store and retrieve information needed to make a diagnosis, Bordage, Grant and Marsden developed a self-administered instrument called the Diagnostic Thinking Inventory.[25] This tool, which contains forty-one statements that are rated using a Likert-type scale, focuses on delineating two essential features of human memory:

- the way in which information is stored (memory structures)
- the way in which information is retrieved (flexibility of thinking)

Although to date there has been limited use of this instrument, the inventory has been validated as an appropriate way of measuring changes in cognitive elements required to make a diagnosis, with increasing levels of clinical experience and training.[25] The DTI has been used, for example, in the evaluation of the cognitive difference between medical students in traditional, as compared to problem-based learning curricula.[68]

1.11 CONCLUSION

The ability of health care professionals to make an accurate clinical diagnosis is regarded as the bedrock of efficient, safe, high-class patient care. It is, therefore, essential that new evidence in the science of clinical reasoning, problem solving and decision-making, continues to steer the direction taken by medical curricula around the world.[69]

Based on the literature included in this review, it is clear that psychologists, health professions educators and clinicians agree that the diagnostic thinking process is not a generic skill and that there is no single set of diagnostic reasoning skills that can be acquired and taught to become an expert diagnostician.[70] Current data do, however, suggest that there are metacognitive strategies which, if accompanied by enriched, well-organized knowledge, may improve the diagnostic competence of medical trainees.

Before concluding this literature review it is essential to provide a global context for the work reported in this dissertation. After sub-Saharan Africa (SSA) emerged from colonial domination in the latter half of the last century, the forty-seven, then new, medical schools in the region, although eroded by political and economic hardship, committed to developing medical curricula that would not only be up to date and relevant, but also focus on reducing the shortage of ‘quality’ doctors practicing on the continent.[71,72,73] In a recent review of the literature describing the state of medical education in SSA, the importance of innovative training strategies in medical curricula, to enhance the diagnostic thinking process of doctors, was once again highlighted.[72]

The work reported in this dissertation explores teaching and learning strategies that speak to this mandate within the resource-limited context of health professions training in sub-Saharan Africa. Educators informed by the research reported in this review, and future work, can serve as powerful change agents in the process of reforming health professions education, and thereby improving health care, one of the most important goals of the 21st century.[74]

1.12 REFERENCES

1. Barrows H, Tamblyn R. Problem-based learning: An approach to medical education. New York: Springer; 1980. Chapter 2, The clinical reasoning process: Problem solving in medicine; p.19-37.
2. Gale J, Marsden P. Medical diagnosis: from student to clinician. Oxford: Oxford University Press; 1983. p.162.
3. Eva K. What every teacher needs to know about clinical reasoning. Medical Education 2004; 39:98-106.
4. Charlin B, Tardif J, Boshuizen H. Scripts and medical diagnostic knowledge: theory and applications for clinical reasoning instruction and research. Academic Medicine 2000; 75:182-190.
5. Fish D, Higgs J. The context for clinical decision making in the 21st century. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p19-31.
6. Norman G, Eva K. Diagnostic error and clinical reasoning. Academic Medicine 2010; 44:94-100.
7. Boshuizen H, Schmidt H. The development of clinical reasoning expertise. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p113-123
8. Lawson A, McElrath C, Burton M, James B, Doyle P, Woodward S, Kellerman L, Snyder J. Hypothetico-deductive reasoning skill and concept acquisition: testing a constructivist’s hypothesis. Journal of Research in Science Teaching 1991; 28:953-970.
9. Sternberg R, Horvath J. A prototype view of expert teaching. Educational Researcher 1995; 24:9-17.
10. Boshuizen H, Schmidt H. On the role of biomedical knowledge in clinical reasoning by experts, intermediates and novices. Cognitive Science 1992; 16: 153-184.

11. Kaufman D, Yoskowitz N, Patel V. Clinical reasoning and biomedical knowledge: Implications for teaching. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p137-151.
12. Patel V, Arocha J, Branch T , Daniel R, Karlin B. Relationships between small group problem-solving activity and lectures in health science curricula. Journal of Dental Education 2004; 8:1058-1080.
13. Jolly B. Problem based learning. Medical Education 2006; 40:494-495.
14. Charlin B, Boshuizen HPA, Feltovich PJ. Scripts and clinical reasoning. Medical Education 2007; 41:1178-1784.
15. Feinstein A. An analysis of diagnostic reasoning: the domain and disorders of clinical macrobiology. Yale Journal of Biology and Medicine 1973; 46:262-283.
16. Feltovich P, Barrows H. Issues of generality in medical problem solving. In: Schmidt, De Volder ML. Tutorials in problem-based learning. Assen, Van Gorcum 1984; p128-142.
17. Schank RC, Abelson R. Scripts, Plans, Goals and Understanding: An inquiry into human knowledge structures. Hillsdale: Lawrence Erlbaum Associates; 1977. p97-100.
18. Norman G, Rosenthal D, Brooks L, Allen S, Muzzin L. The development of expertise in dermatology. Archives of Dermatology 1989; 125:1063-1068.
19. Schmidt HG, Norman GR. A cognitive perspective on medical expertise and implications. Academic Medicine 1990; 65: 611-621.
20. Patel V, Evans D, Kaufman D. Reasoning strategies and use of biomedical knowledge by students. Medical Education 1990; 24:129-136.
21. Mamede S, Schmidt HG, Rikers R. Diagnostic errors and reflective practice in medicine. Journal of Evaluation in Clinical Practice 2007; 13:138-145.
22. Patel V, Glaser R, Arocha J. Cognition and expertise: acquisition of medical competence. Clinical and Investigative Medicine 2000; 23: 256-260.
23. Patel V, Arocha J, Kaufman D. Diagnostic reasoning and expertise. Psychology of Learning and Motivation: Advances in Research and Theory 1994; 31:137-252.

24. Ausubel, DP. Meaningful learning and retention: Intrapersonal cognitive variables. Review of Educational Research 1961; 31:500-510. Available from: http://www/jstor.org/stable/1168901
25. Bordage G, Grant J and Marsden P. Quantitative assessment of diagnostic ability. Medical Education 1990; 24:413-425.
26. Les Gold A, Rubinson H, Feltovich P, Glaser R, Kloper D, Wang Y. Expertise in a complex skill: Diagnosing X-ray pictures. In: Chi, M, Glaser R, Farr M. The nature of expertise. Hillsdale, New Jersey, England: Lawrence Erlbaum Associates; 1988. p311-342.
27. Ericsson K. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. Academic Medicine 2004; 79:70-81.
28. Mamede S, Schmidt HG, Penaforte JC. Effects of reflective practice on the accuracy of medical diagnoses. Medical Education 2008; 42:468-475.
29. Mamede S, Schmidt H, Rikers R, Penaforte JC, Coelho-Filho J. Influence of perceived difficulty of cases on physicians diagnostic reasoning. Academic Medicine 2008; 83:1210-1216.
30. Epstein RM. Mindful practice. Journal of the American Medical Association 1999; 282:833-839.
31. Jensen G, Resnik L, Haddad A. Expertise and clinical reasoning. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p123-137.
32. Mamede S, Schmidt HG. The structure of reflective practice in medicine. Medical Education 2004; 38:1302-1308.
33. Post DL. Medical Problem Solving: An Analysis of Clinical Reasoning. Bulletin of the New York Academy of Medicine. 1979; 55:886-887.
34. Elstein A, Schwartz A. Clinical problem solving and diagnostic decision-making: selective review of cognitive literature. British Medical Journal 2002; 324:729-732.
35. Epstein S. Integration of the cognitive and psychodynamic unconscious. American Psychologist 1994; 49:709-724.
36. Evans J. Dual processing accounts of reasoning, judgement and social cognition. Annual Review of Psychology 2008; 59:255-278.

37. Stolper E, van Royen P, van de Wiel M, van Bokhoven M, Houben P, van der Weijden T, Dinant G. Consensus on gut feelings in general practice. BMC Family Practice 2009; 17:10-66.
38. Gale J, Marsden P. Clinical problem solving: the beginning process. Medical Education 1982; 16:22-26.
39. Friedman C, Martz J, Swensson R. Visual information and the diagnosis of chest pain. Academic Medicine 1994; 69:528 -530.
40. Neufeld V, Barrows H. Clinical problem solving by medical students: a cross-sectional and longitudinal analysis. Medical Education 1981; 15:315-22.
41. Dewey J. How we think. Boston: Health 1933. Chapter 9, Meaning: or concepts and understanding; p116-134. Available from: http://rci.rutgers.edu/~tripmcc/phil/dewey-hwt-pt1-selections.pdf
42. Mamede S, van Gog T, Moura A, de Faria R, Peixoto J, Rikers R, Schmidt H. Reflection as a strategy to foster medical students' acquisition of diagnostic competence. Medical Education 2012; 46:464-472.
43. Bargh J, Chartrand T. The unbearable automaticity of being. American Psychology 1999; 54:462-479.
44. Norman G, Sherbino J, Dore K, Wood T, Young M, Gaissmaier W, Kreuger S, S Monteiro. The etiology of diagnostic errors: A controlled trial of System 1 versus System 2 reasoning. Academic Medicine 2014; 89:277-284.
45. Schimdt H, Pikers RMJ. How expertise develops in medicine: knowledge encapsulation and illness script formation. Medical Education 2007; 41:1133-1139.
46. Croskerry P. Critical thinking and reasoning in Emergency Medicine. In: Croskerry P, Cosby K, Schenkel S, Wears R. Patient safety in Emergency Medicine. Philadelphia: Lippincott Williams & Wilkins; 2008. 213-218.
47. Smith E, deCoster J. Dual process models in social and cognitive psychology: conceptual integrations and links to underlying memory systems. Personality and Social Psychology Review 2000; 4:108-131.
48. Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. Academic Medicine 2003; 78:775-780.
49. Graber M. Diagnostic error in internal medicine. Archives of Internal Medicine 2005; 165:1493-1499.

50. Croskerry P, Petrie D, Reilly J, Tait G. Deciding about fast and slow decisions. Academic Medicine. 2014; 89:197-200.
51. Patel V, Evans D, Groen G. Biomedical knowledge and clinical reasoning. In: Evans D, Patel V. Cognitive science in medicine: biomedical modelling. Cambridge: MIT press; 1989.
52. Barrows HS. Practiced-based Learning: Problem based learning applied to medical education. Springfield: South Illinois University School of Medicine 1994. Chapter 1, Problem based learning; p1-4.
53. Trowbridge RL, Dhaliwal G, Cosby KS. Educational agenda for diagnostic error reduction. British Medical Journal Quality and Safety 2013; 22:ii28-ii32
54. Mamede S, van Gog T, Sampaio A, de Faria R, Maria J, Schmidt H. How can students diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. Academic Medicine 2014; 89:121-27.
55. Jerome P. Kassirer. Teaching clinical reasoning: Case-based and coached. Academic Medicine 2010; 85:1118-1124.
56. Knowles M, Holton E, Swanson R. The adult learner: The definitive classic in adult education and human resources development. 8th edition. New York: Routledge; 2015. Chapter 2, Exploring the world of learning.
57. Van Gog T, Ericsson K, Remy M, Rikers J, Paas F. Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. Educational Technology Research and Development 2005; 53:73-81.
58. Van Merrienboer J, Sweller J. Cognitive load theory and complex learning: Recent developments and future directions. Educational Psychology Review 2005; 7:147-177.
59. Schuwirth L. Is assessment of clinical reasoning still the Holy Grail? Medical Education 2009; 43:298-300.
60. Mc Carthy W, Gonnella J. The simulated patient management problem: a technique for evaluating and teaching clinical competence. British Journal of Medical Education 1967; 1:348-352.
61. Goran M, Williamson J, Gonnella J. The validity of the patient management problems. Journal of Medical Education 1973; 48:171-177.

62. Grosse M, Wright B. Psychometric characteristics of scores on a patient-management problem test. Educational and Psychological Measurements 1988; 48:297-305.
63. Durak H, Caliskan S, Bor S, van der Vleuten C. Use of case-based exams as an instructional teaching tool to teach clinical reasoning. Medical Teacher 2007; 29:170-174.
64. Charlin B, Roy L, Brailovsky C, Goulet F, van der Vleuten C. The Script Concordance Test: a tool to assess the reflective clinician. Teaching and Learning in Medicine 2000; 12:189-195.
65. Groves M, Dick M, McColl G, Bilszta J. Analysing clinical reasoning characteristics using a combined methods approach. BMC Medical Education 2013; 13:144.
66. Groves M, Scott I, Alexander H. Assessing clinical reasoning: a method to monitor its development in a PBL curriculum. Medical Teacher 2002; 24:507-515.
67. Hayes K. Written assessment. In: Walsh K. Oxford Textbook of Medical Education. Oxford University Press 2013; 549-563.
68. Gehlhar K, Klimke-Jung K, Stosch C, Fischer M. Do different medical curricula influence self-assessed clinical thinking in students? German Medical Science Gesellschaft für Medizinische Ausbildung 2014; 31:11-20.
69. Greysen S, Mullan F. Medical education in sub-Saharan Africa: a literature review. Medical Education 2011; 45:973-986.
70. Willingham D. Critical thinking: Why is it so hard to teach? American Educator 2008; 109:21-29.
71. High Level Forum on the Health MDGs. Addressing Africa's Health Workforce Crisis: an avenue for action 2004. http://www.hlfhealthmdgs.org/Documents/AfricasWorkforce-Final.pdf.
[Accessed 23 October 2015 via - siteresources.worldbank.org]
72. O Brien HR. The dawn of medical education in tropical Africa. Journal of Medical Education 1958; 33(8): 553-64.
http://pdfs.journals.lww.com/academicmedicine/1958/08000/The_Dawn_of_Medical_Education_in_Tropical_Africa_.1.pdf

73. World Health Organization. WHO Avicenna World Directory of Medical Schools. 2007. http://avicenna.ku.dk/database/WHO_directory/. [Accessed 23 October 2015]
74. Frenk J, Chen L, Bhutta Z, Cohen J, Crisp N, Evans T, Fineberg H, Garcia P, Yang K, Kelley P, Kistnasamy B, Meleis A, Naylor D, Pablos-Mendez A, Reddy S, Scrimshaw S, Sepulveda J, Serwadda D Zurayk H. Health professionals for a new century: transforming education to strength health systems in an interdependent world. The Lancet 2010; 376:1923-1958.

CHAPTER TWO

THE EFFECT OF STRUCTURED REFLECTION ON THE DIAGNOSTIC ACCURACY OF POSTGRADUATE TRAINEES DURING REAL PATIENT ENCOUNTERS

2.1 INTRODUCTION

The ability to make a diagnosis is a multifaceted, cognitive process that serves as the cornerstone of clinical practice and is central to the provision of efficient, high-class patient care.[1,2,3,4,5] One of the most challenging aspects of clinical practice is the need to make an accurate provisional diagnosis at the time of the first patient consultation in order to reduce the burden of patient morbidity and mortality ascribed to diagnostic error.[6,7,8,9]

Unravelling the cognitive structures and strategies clinicians use to generate, test and verify diagnoses has been the work of educational scientists for more than half a century.[10,11] Despite a considerable body of research, teaching strategies that improve the diagnostic competence of clinical trainees is a topic that lacks robust, empiric evidence.[11,12,13,14]

Delineation of this process has resulted in numerous hypothetical models, which have steered the direction taken by medical educators in attempts to develop and enhance the diagnostic competence of trainees. Over the past decade, reflection has been highlighted as a critical metaskill required to develop and maintain clinical diagnostic expertise.[15] In 2004, Mamede and colleagues proposed a multidimensional model of reflective practice in medicine and developed a research strategy to evaluate the impact of a process of structured reflection on diagnostic accuracy.[16]

This process has been shown to improve the diagnostic accuracy of medical residents when faced with complex clinical "paper" cases.[17,18] Furthermore, conscious thought and deliberation is better than deliberation without attention when comparing the diagnostic accuracy of intermediate level medical students with that of novices.[19] Structured reflection in an experimental setting has also been shown to improve students' knowledge of illness exemplars and alternative diagnoses.[12] It has been suggested that this strategy may benefit medical trainees engaging in diagnostic reasoning processes using simulated patient case scenarios or real patient encounters.[20]

To date, the bulk of the evidence supporting the use of reflective strategies to make accurate and improved clinical diagnoses has largely been determined in experimental conditions using medical students (novice clinicians) and 'paper-cases'.[12,17,18,21,22] The impact of structured reflection on diagnostic accuracy during real patient encounters has not been evaluated. This represents an important gap in the literature because contextual factors,[23] and factors associated with patient-practitioner clinical encounter breakdown,[24] typical of real clinical practice, have been shown to increase cognitive load and decrease diagnostic accuracy.[9,25] Ideally, cognitive strategies aimed at improving outcome, should be studied in environments where the challenges of day-to-day clinical practice are taken into account.

Furthermore, all the published work on diagnostic accuracy has used case descriptions that include the results of key investigations.[12,17,18] Unfortunately, this also does not reflect real clinical practice, where the real challenge is to make an accurate provisional/working diagnosis during the first encounter with the patient to guide the selection of key investigations to confirm a diagnosis. The accuracy of the initial working/provisional diagnosis may have significant implications regarding the quality of care the patient receives,[6] particularly resource limited settings where access to investigations is limited.

While clinical reasoning research continues to explore the ways in which clinicians make diagnoses, the cognitive structures and processes required to store and recall the information required to make a diagnosis in the first instance, has received less attention in the medical education literature. What is known is that novice clinicians/medical students are unlikely to have developed an enriched core of domain-specific knowledge that forms the scientific foundation of clinical reasoning.[26,27] The Diagnostic Thinking Inventory (DTI) (Appendix A), developed by Bordage, Grant and Marsden in the early 1980s, provides a self-reported measure of knowledge structures (memory) and flexibility of thinking (recall) based on a set of knowledge-independent statements scoring using a Likert rating scale. The DTI, implemented, validated[28,29] and analysed in conjunction with other cognitive or psychometric tests[30] aims to provide insight into the accessibility of memorized information, which ultimately determines how a clinician sees, interprets and structures a clinical problem to be solved.[31] The insight provided by such information may be useful when deciding on efficacy of proposed/implemented teaching strategies aimed at improving diagnostic competence.

Given the limitations associated with studying diagnostic expertise and cognitive strategies in experimental settings as described, this study was conducted to determine the impact of structured reflection on the diagnostic accuracy of medical doctors in real patient encounters. The study specifically focused on making a working/provisional diagnosis at the bedside of real patients using history and physical examination findings only. Finding ways of improving diagnostic accuracy at the bedside can therefore make an important contribution to improving patient morbidity and mortality as well as curtailing the spiralling costs of health care.

2.2 METHODS

2.2.1 Participants

All registrars (postgraduate specialist trainees) working in the Department of Medicine at the University of Cape Town (UCT), in Cape Town, South Africa during 2014, were invited to participate in the study.

2.2.2 Study design

The impact of structured reflection on diagnostic accuracy was prospectively evaluated by performing a four-stage diagnostic process (Figure 2.1) during 18 weekly bedside tutorials which formed part of the postgraduate clinical training programme at UCT. These tutorials, conducted by an attending physician with more than 20 years of undergraduate and postgraduate teaching experience, took place at the bedside of medical patients admitted to Groote Schuur Hospital in Cape Town, one of the largest academic training hospitals in sub-Saharan African.[32]

2.3 PROCEDURE

Ethical approval for the study was obtained from the Human Research Ethics Committee of the Faculty of Health Science at UCT (HREC: 762/2013) (Appendix B).

Participation was voluntary and written consent was obtained from all participants prior to entering the study. Patients gave verbal consent prior to participation in the bedside tutorials. Patients and trainees did not receive any compensation.

At the time of entering the study, participants completed a Diagnostic Thinking Inventory questionnaire to evaluate their memory structures and flexibility in thinking, as reported by Bordage and colleagues.[31]

2.3.1 Case Selection

In preparation for each tutorial, a delegated registrar was responsible for organizing and identifying two potential patients who met three basic criteria:

- the patient had a clinical presentation listed in the curriculum published by the College of Physicians of South Africa [33]
- the patient was well enough to participate in the tutorial
- the patient was willing to participate in the tutorial

The patients were discussed with the attending physician conducting the tutorial and one case was selected. A senior registrar, preparing for Part II of the College of Physicians of South Africa[33] fellowship examination was asked to interview and examine the patient one hour before the tutorial took place. The trainee was not given any information about the patient and was asked not to consult the patient notes.

Prior to commencing each tutorial the attending physician personally interviewed and examined the patient and made a working/provisional diagnosis. Access to patient notes and diagnostic investigations were made available to the physician when further diagnostic clarity was required. This was done to check reliability in order to minimise potential mistakes.

2.3.2 Case Tutorial

Each bedside tutorial was conducted in four stages as shown in Figure 2.1.

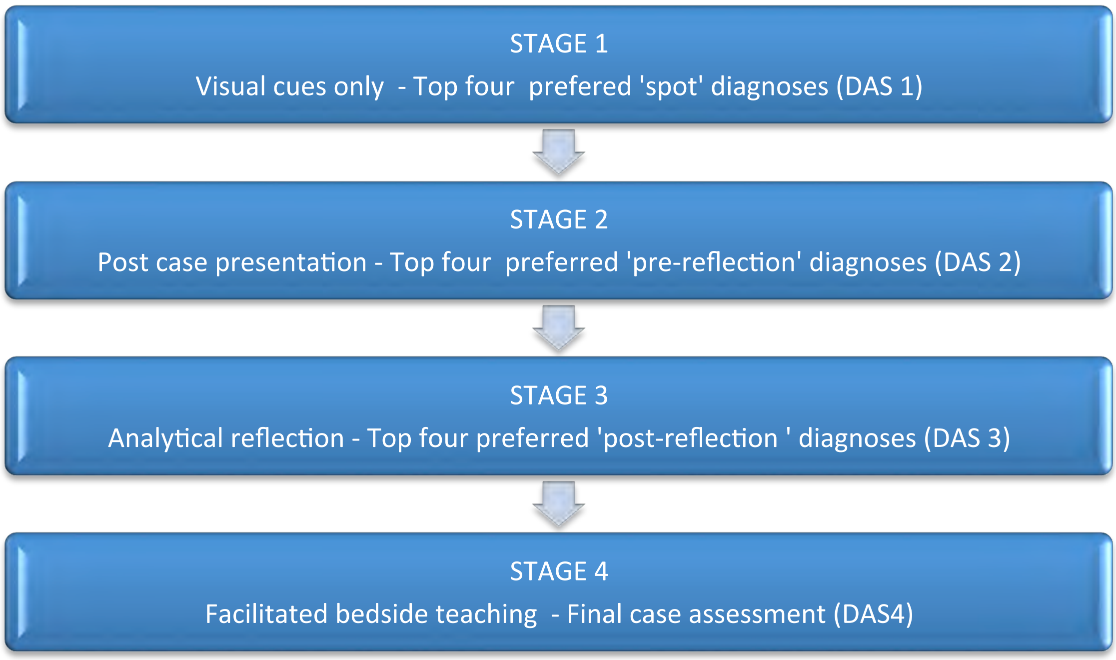

Figure 2.1: Research method outline

In Stage 1, the attending physician provided the tutorial participants with the patient's presenting complaint, for example – shortness of breath, and asked them to make an immediate 'spot' diagnosis on the basis of the patient's presenting complaint and any visual cues identified during a 5-minute period of silent observation upon arrival at the bedside. Participants recorded their four preferred diagnoses, in order of preference, on a blank A5 card, which was submitted before proceeding to the next stage of the tutorial. The data recorded on these cards were used to calculate a diagnostic accuracy score(DAS) for stage 1 (DAS 1).

In Stage 2, the registrar who interviewed and examined the patient presented the key features of the history and physical examination only, i.e. a diagnosis was not offered at this stage of the tutorial. Thereafter, participants were asked to immediately record their four preferred diagnoses in order of preference, on a blank A5 card, which was submitted before proceeding to the next stage of the tutorial. The data recorded on these cards were used to calculate DAS 2.

In Stage 3, participants moved to a side room in the ward to review a set of digitally projected case notes detailing all the key findings reported during the case presentation at the bedside. They were then asked to complete a Structured Reflection Chart (Appendix C) which was table comprising of four blank columns on an A4 sheet of paper. Working from left to right, participants completed the table as follows:

- Column 1 was used to record the preferred four diagnoses, in order of preference, as recorded at the end of stage 2 of the tutorial;
- Column 2 was used to record the key findings (including the history and physical examination) that supported the diagnoses listed in column 1 of the table;
- Column 3 was used to record the findings that did not support the diagnoses listed in column 1;
- Column 4 was used to list any key features that were not mentioned, i.e. ‘missing features’ that would have been useful in ruling a specific diagnosis in or out. Participants were free to ask the presenting registrar about the ‘missing features’ in the event that these were accidentally omitted from the bedside presentation.

Participants repeated the four steps of the structured reflection process for all four preferred diagnoses recorded at the end of Stage 2 of the tutorial. In addition, they were asked to record and repeat the reflection process for any other diagnoses that came to mind during the process of reflection. At the end of the 15-mintue period of reflection, registrars recorded their top four diagnoses in order of preference on a blank A5 card, which was submitted before proceeding to the final stage of the tutorial. The data recorded on these cards were used to calculate DAS 3.

Stage 4 during the tutorial, the registrar who presented the patient provided his/her working diagnosis and the supporting key features. Thereafter, the attending physician initiated a bedside discussion of case, specifically focusing on the key clinical findings (forceful features)[3] of the history and physical examination and identified any diagnostic errors related to the omission or misinterpretation of key clinical findings. In closing, the attending physician provided an interpretation of the case from the perspective of an expert clinician. Participants were then asked to record their final assessment of the case on a blank A5 card, which was submitted at the end of the tutorial. The data recorded on these cards were used to calculate DAS 4.

At the end of each tutorial, once all the experimental data (DAS 1-4) had been collected, the attending physician, together with the participants, reviewed any additional information contained in the patient's hospital records, including investigations performed during the patient's hospital stay. This provided final closure of the case discussion and was used to formulate the final assessment recorded in Table 2.

2.4 DATA ANALYSIS

All data submitted by participants were anonymised using an alphanumeric identifier. A Diagnostic Accuracy Score (DAS) was calculated (summed) for each participant at the end of each stage of the tutorial process(DAS1-4) using the scoring method described in Table 2.1, and entered into a Microsoft Excel Spreadsheet®. The scoring method was designed to reflect two aspects of diagnostic accuracy:

- correctness of the working diagnosis made, i.e. completely correct = 2 points, partially correct = 1 point and incorrect = 0 points
- position (rank order) of the partially or completely correct diagnosis, i.e. at the top of the list = 2 points, not at the top of the list = 1 point and not on the list = 0 points

Table 2.1: Diagnostic accuracy scoring system

Diagnosis and rank order	Score
Incorrect diagnosis	0
Partially correct diagnosis but incorrect rank order	1
Partially correct diagnosis and correct rank order	2
Correct diagnosis but incorrect rank order	3
Correct diagnosis and correct rank order	4

Statistical analysis was performed using the software, R® version 3.2.1. Median scores for each stage of the diagnostic thinking process (DAS1 – DAS4) were compared using the Friedman test, a nonparametric version of the repeated measures ANOVA. The Wilcoxon signed-rank test was used to further compare median values for pairs of data – DAS 1 versus DAS 2, DAS 2 versus DAS 3, DAS 3 versus DAS 4, DAS 1 versus DAS 3 (a measure of independent performance). A Bonferroni correction was applied and a p-value of 0.0167 or less was considered significant.

The relationship between participants DTI scores and post-reflection DAS was investigated through linear regression analysis and a Pearson product moment correlation coefficient.

2.5 RESULTS

2.5.1 Participants

Of the 66 registrars in the department, 61 (92.4%) participated in the study. Seven were excluded (incomplete data) and the data from the remaining 55 participants (90.2%) was included in the final analysis. The mean age of the participants was 32 years (SD 3.4 years); 24 (43.6%) were women and each participant had an average of six years clinical practice experience including two years internship and one year obligatory community service practice for doctors registered with the Health Professions Counsel of South Africa.[34]

2.5.2 Diagnostic Events

Eighteen bedside tutorials were conducted during the study. Each participant provided one diagnostic event on completion of DAS 1 – 4 for a given tutorial. A total of 212 diagnostic events were included in the study. For each tutorial the final diagnosis, as listed in Table 2.2, was made at the end of the bedside teaching session based on key clinical findings (interview and physical examination) and the the results of investigations available in the case notes.

Table 2.2: Clinical case, presenting problem and preferred working diagnosis

Case	Presenting problem	Final assessment
Case 1	Haemoptysis	17-year-old man with post pulmonary tuberculosis (TB) bronchiectasis, complicated by ongoing haemoptysis secondary to rifampicin-induced thrombocytopenia
Case 2	Progressive difficulty in walking	29-year-old HIV-positive woman (stage 4 defining disease), with a lumbosacral polyradiculopathy secondary to reactivated disseminated tuberculosis
Case 3	Acute onset chest pain	21-year-old man with end stage kidney disease (chronic glomerulonephritis - IgA nephropathy) complicated by septic pulmonary emboli from a dialysis catheter-related blood stream infection
Case 4	Headache	55-year-old HIV-negative woman with a fungal meningitis (Cryptococcus neoformans) being worked up for a primary or secondary immunodeficiency syndrome later confirmed to have systemic lupus erythematosus
Case 5	Heart murmur and shortness of breath	27-year-old man with mixed mitral and aortic valve disease, secondary to childhood rheumatic heart disease complicated by severe pulmonary hypertension confirmed on echocardiography
Case 6	Joint/back pain	21-year-old female with a ventricular septal defect complicated by blood culture proven infective endocarditis
Case 7	Progressive dyspnoea	48-year-old woman with previous acute myeloid leukaemia and a bone marrow transplant complicated by a graft-versus-host disease, interstitial lung disease and pulmonary hypertension
Case 8	Lower limb weakness and urinary incontinence	48-year-old woman previous treated breast cancer presenting with proximal myopathy most likely due to a paraneoplastic phenomenon or hypothyroidism
Case 9	Fatigue	51-year-old woman with pancytopenia and a massive hepatosplenomegaly due to a haematological malignancy confirmed on bone marrow biopsy
Case 10	Dysarthria	29-year-old female patient presenting with a stroke-like syndrome from systemic lupus erythematosus and antiphospholipid syndrome

Case	Presenting problem	Final assessment
Case 11	Swollen legs	37-year-old woman with nephrotic syndrome secondary to an HIV associated nephropathy
Case 12	Recurrent episodes of collapse	29-year-old woman with hypopituitarism secondary to Sheehan's syndrome confirmed MRI and appropriate blood tests
Case 13	Dysphagia	54-year-old male patient with multiple strokes secondary to severe atherosclerotic disease confirmed on CT imaging
Case 14	Lymphadenopathy	34-year-old HIV-positive man with a superior vena cava syndrome as a result of external compression by significant generalized lymphadenopathy due to disseminated tuberculosis
Case 15	Short stature	36-year-old woman with childhood-onset rheumatoid arthritis resulting in stunted growth and multiple vertebral fractures due to steroid-induced osteoporosis confirmed by imaging
Case 16	Visual loss	56-year-old woman with a suprasellar mass lesion and raised intracranial pressure later confirmed to be myeloma with optic chiasm compression
Case 17	Pulmonary hypertension	57-year-old woman with longstanding rheumatoid arthritis and interstitial lung disease complicated by pulmonary hypertension confirmed by echocardiography
Case 18	Diplopia	82-year-old man with a 3rd nerve palsy secondary to an embolic stroke due to severe atherosclerotic carotid artery disease

2.5.3 Analysis

Table 2.3 shows the number of participants that attended each bedside tutorial (n) and the median diagnostic accuracy scores (DAS) and interquartile ranges for participants captured.

Table 2.3: Diagnostic accuracy scores at each stage of the diagnostic process

Case	n.	DAS 1 (median +IQR)	DAS 2 (median +IQR)	DAS3 (median +IQR)	DAS4 (median +IQR)
1	18	0.50 (0.00-1.00)	2.00 (1.00-3.00)	3.00 (1.00-4.00)	4.00 (4.00-4.00)
2	13	1.00 (0.00-2.25)	2.00 (1.00-2.50)	2.00 (1.75-3.25)	4.00 (4.00-4.00)
3	11	0.00 (0.00-0.75)	2.00 (0.25-2.00)	3.00 (1.25-4.00)	4.00 (4.00-4.00)
4	12	1.00 (0.50-1.00)	1.50 (1.00-2.00)	1.00 (1.00-2.00)	4.00 (4.00-4.00)
5	15	1.00 (1.00-2.00)	2.00 (2.00-2.00)	2.00 (2.00-3.75)	4.00 (4.00-4.00)
6	17	1.00 (0.00-1.50)	2.00 (2.00-3.00)	2.00 (2.00-4.00)	4.00 (4.00-4.00)
7	12	0.00 (0.00-0.00)	2.00 (1.00-2.00)	2.00 (1.50-2.00)	4.00 (4.00-4.00)
8	5	0.00 (0.00-0.25)	2.00 (1.75-2.50)	2.00 (1.75-3.25)	4.00 (4.00-4.00)
9	15	1.00 (0.00-1.00)	1.00 (1.00-2.75)	3.00 (1.00-3.75)	4,00 (3.25-4.00)
10	11	1.50 (0.00-2.00)	2.50 (1.00-4.00)	2.00 (2.00-4.00)	2.00 (2.00-4.00)
11	9	3.00 (1.75-3.25)	0.00 (0.00-3.25)	0.00 (0.00-3.25)	4.00 (3.00-4.00)
12	14	0.00 (0.00-1.00)	1.00 (0.00-2.00)	2.00 (1.00-4.00)	4.00 (4.00-4.00)
13	11	2.00 (0.25-2.00)	3.00 (3.00-3.75)	3.00 (3.00-4.00)	4.00 (4.00-4.00)
14	9	2.00 (1.75-2.00)	2.00 (1.00-3.25)	2.00 (1.75-4.00)	4.00 (4.00-4.00)
15	11	1.00 (0.00-3.00)	3.00 (3.00-4.00)	3.00 (3.00-4.00)	4.00 (4.00-4.00)
16	12	0.00 (0.00-0.50)	2.00 (1.00-2.00)	2.00 (1.00-2.00)	4.00 (4.00-4.00)
17	8	2.00 (1.00-2.50)	2.00 (1.50-3.50)	3.50 (2.50-4.00)	4.00 (4.00-4.00)
18	9	0.00 (0.00-1.25)	1.00 (0.00-2.25)	2.00 (0.75-2.00)	4.00 (3.50-4.00)
MEAN		0.94 (0.35-1.51)	1.83 (1.19-2.76)	2.19 (1.57-3.40)	3.89 (3.76- 4.00)

There was a statistically significant difference between the median scores of the respective stages of the diagnostic reasoning process ($\chi^2(3)$ = 406.34, p value <

0.001). Further comparison of the median values of each stage of the process were significantly different – DAS 1 versus DAS 2 (Z = 8.66, p value < 0.001), DAS 2 versus DAS 3 (Z = 4.98, p value < 0.001), DAS 3 versus DAS 4 (Z = 10.14, p value value <0.001) and DAS 1 versus DAS 3 (Z = 9.81, p value <0.001) (Figure 2.2).

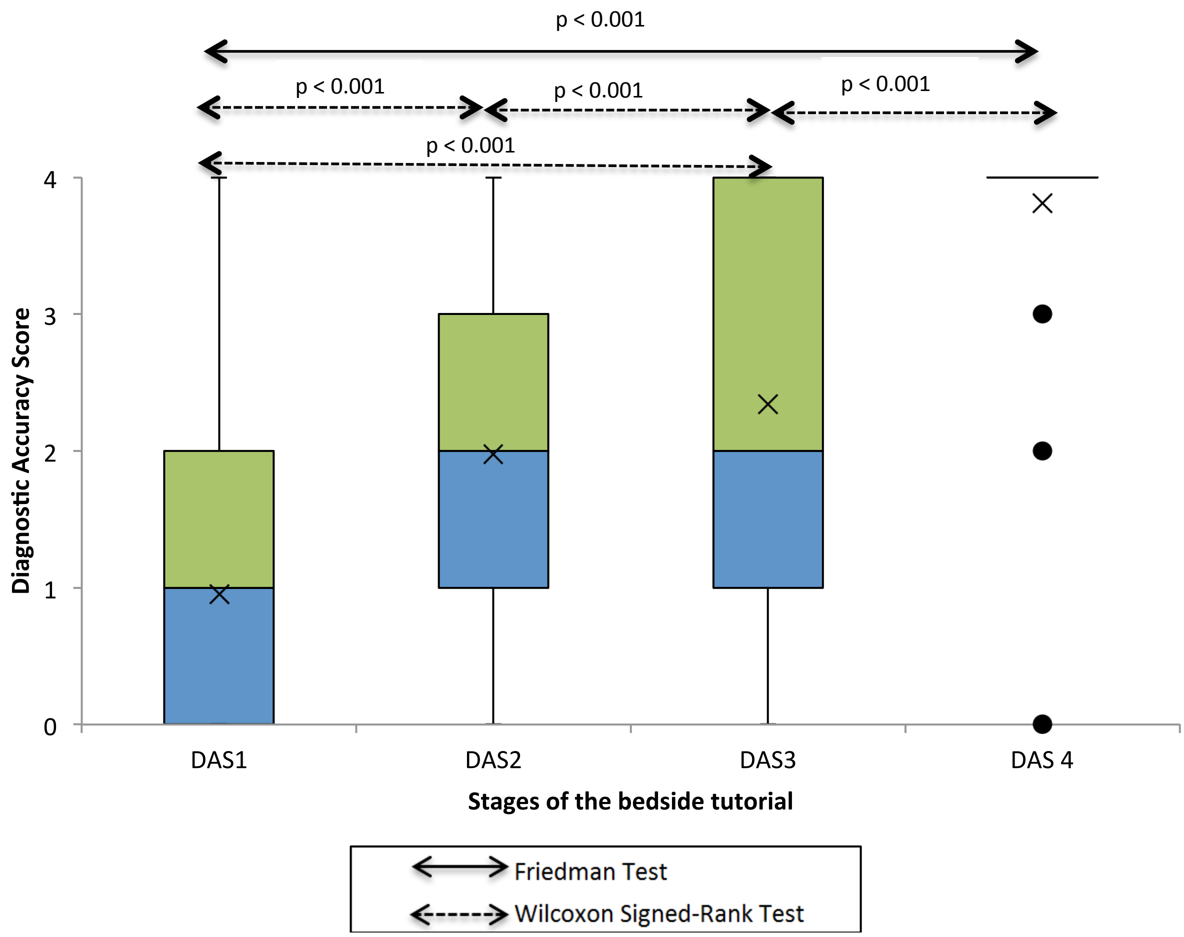

Figure 2.2: Comparison of Diagnostic accuracy scores (DAS) using boxplots for each stage of the diagnostic process, with the median score (solid line), mean score (cross), upper and lower quartile (box) and minimum and maximum scores (black dash) represented. In DAS 4, the solid dots represent three outliers. The respective p-values for both the Friedman test and the Wilcoxon signed-rank tests are provided.

2.6 DIAGNOSTIC THINKING INVENTORY

Figure 2.3 shows the mean DTI scores for 46 participants included in this study who completed a DTI as compared to the mean DTI scores of third year medical students, house officers, general practitioners and registrars, as reported by Bordage and colleagues.[31]

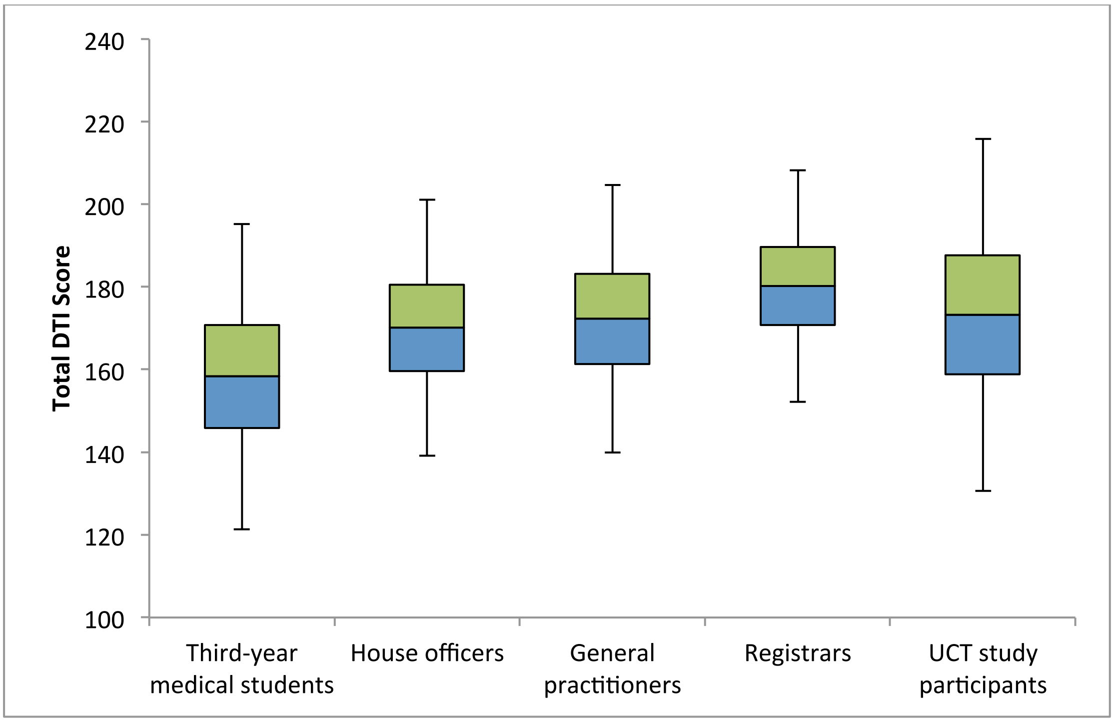

Figure 2.3: Comparison of the Diagnostic Thinking Inventory (DTI) scores of University of Cape Town (UCT) study participants and a range of UK trainees and General Practitioners as reported by Bordage et al in 1990.[31] The boxplots show mean scores, interquartile range (1st and 3rd) and the 97.5% confidence interval.

A Pearson product moment correlation coefficient of 0.3 indicates a limited correlation between participant DTI scores and DAS 3. A linear regression does however indicate DTI as a significant factor in determining DAS 3 (p value = 0.035). The relationship between the two is shown in Figure 2.4.

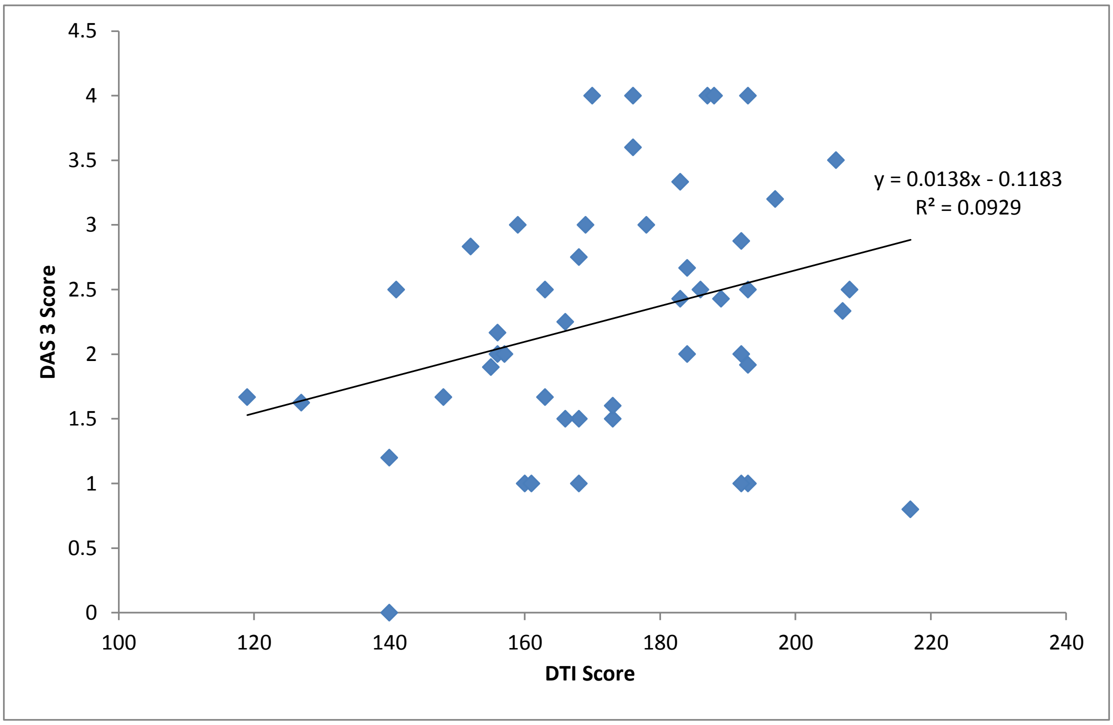

Figure 2.4: Relationship between DAS 3 and DTI scores

2.7 DISCUSSION

The findings of this study show that structured reflection, as described by Mamede and colleagues, had a positive effect on the diagnostic accuracy of postgraduate trainees during real patient encounters. The study conditions in this work represented authentic clinical practice as compared to previous studies in which undergraduates (medical or non-medical) were required to make diagnoses using simulated objective structured clinical examinations (OSCE) or paper cases based on real patient scenarios.[12,17,18,21,22] This study has therefore addressed an important gap in the literature by using real patient encounters where construct irrelevant variables that do not contribute to, or which may detract from the diagnosis (red herrings), are present. Reflection, a key metaskill needed for clinical reasoning,[16] provided registrars at the bedside with a tool that enabled them to improve their diagnostic accuracy.

Constructing multiple hypotheses and reflecting on the validity and implications of each, brings about an enriched understanding of the problem whilst providing an efficient and thoughtful approach to solving it.[35] One can postulate that this cognitive reflective framework, although almost a century old, can be implemented in the real patient encounters of today to improve diagnostic accuracy by reducing potential errors and minimize the negative effect they have on patient care. Reflection-in-action when faced with uncertain circumstances activates mental representation of disease allowing the clinician to respond to novel situations.[36] Future work needs to pay close attention to the gap between pre- and post-reflection diagnostic accuracy, looking specifically at how the activation of mental representation occurs at the bedside, its effect on clinical error and the implications these will have on patient outcomes.

Reflective practice has been seen to be associated with the generation of more accurate hypotheses when used in complex cases.[17] However, we would like to propose that the prevalence of certain cases might be more influential in determining the diagnostic outcome and the influence had by analytical reflection as opposed to ‘case complexity’. ‘Case 1’ in this study is a prime example, where many registrars were able to make an intuitive diagnosis based on their experience of managing high volumes of patients with pulmonary tuberculosis (TB). Rifampicin-induced thrombocytopenia is a rare and complex phenomenon[37] however, in the context in which we practice medicine, where TB prevalence is extremely high, we are continually exposed to the drug and its side effects. Repeated exposures to such cases doesn’t take away from the fact that the case remains complex. It does however reduce its ‘rarity’, which we feel is more significant than complexity when it comes to designing a study to test the outcome that specific learning strategies have on diagnostic accuracy. Trainees need to adopt a more structured approach when addressing rare, first time cases and we feel that it is under these conditions that structured reflection may have a dominant role to play.

This study also showed that in this setting, where visual information is often limited, accuracy of an immediate spot diagnosis at the outset of a consultation was poor. It is widely recognized that the process of clinical problem solving commences as soon as any information about a patient, including visual cues, are obtained.[38] Pattern recognition depends on well-constructed, dense ‘illness scripts’ that result in clinicians actively seeking further information until the pattern is recognized and defined as a potential diagnostic interpretation. Although visual cues are needed to stimulate the recognition of clinical patterns, clinicians require the metaskill to access preformed illness scripts so that diagnostic errors can be avoided. The challenge remains how we identify such cognitive errors and situations in which they are compounded, and make use of taught skill to ensure that they are no longer introduced into clinical reasoning.

The role played by the bedside teacher in facilitating the acquisition of immediate diagnostic accuracy was made evident between stage 3 to stage 4 of the tutorial. The significant improvement between DAS 3 to DAS 4 highlights the importance of facilitated bedside teaching. The teacher ensures that the dynamic learning oppurtunity afforded by real life bedside teaching is maximised, closing the gap in the teaching process. Although not a primary objective of this paper, and given the limitations associated with having only one attending physician with a structured, yet not defined process of facilitation, such a finding provides an area where future work is needed to delineate the exact role of the facilitator during real life bedside tutorials.

Lastly, unknown to us is the way in which reflective skill influences illness scripts and whether or not repeated use of this metaskill expedites the development of clinical expertise. What we have identified is that there is a correlation between clinical reasoning ability (an indirect measure of expertise) that is influenced by analytical reflection and diagnostic accuracy. Although not perfectly correlated, our univariate regression of DTI scores to DAS supports the need for academic curricula to adopt teaching strategies, such as analytical reflection, that may enhance clinical reasoning and ultimately improve diagnostic accuracy. Future work is required to take this further and identify other major factors such as age, experience and disease prevalence that may or may not influence diagnostic outcome, from which curricula frameworks can take direction.

Our study had several limitations.

First, although regarded as a single centre study, our trainees and study participants originated from a range of centres distributed all over Africa. This multicentre alternative provided data from graduates ranging from South Africa, Zimbabwe, Botswana, Malawi, Zambia, Kenya, Benin and Libya.

Second, our cohort size, and in particular the number of participant patient encounters, which relied on the bedside tutorial attendance over and above daily after hour demands, prevented us from accurately assessing whether analytical reflection can be ‘learnt’ over a period of time.

Third, our study was designed to provide a quantitative evaluation of the impact that analytical reflection has on diagnostic accuracy in real patient encounters. There is a clear need to assess the quality of structured reflection and how this may influence diagnostic outcome. Future work is aimed at assessing this, looking at the role of a good reflective practitioner and the effect is has on diagnostic accuracy.

Lastly, the quality of trainees’ illness scripts and domain specific knowledge, an essential component of expert clinical reasoning[39] was not evaluated in this study. Although our cohort of participants had all passed their undergraduate degrees, providing the study with a baseline measure of core knowledge, our method lacked the ability to accurate evaluate this. Irrespective of high quality problem solving skills, if the pieces of the puzzle are lacking, the picture can never be constructed.

2.8 CONCLUSION

In conclusion, structured reflection can be used as a bedside teaching tool to improve diagnostic accuracy during real patient encounters. The facilitator plays a vital role in ensuring that the gap in the teaching process is closed and that the tutorial potential is maximised and truly completed. The DTI appears to be a valid way of assessing a measure of clinical reasoning and expertise amongst a cohort of South African medical registrars. Furthermore, there is a positive correlation between clinical reasoning and diagnostic accuracy. Avenues to be further explored by future research will need to take into account the quality of reflection, the quality of illness scripts, the type of cases (rare versus complex) that draw maximum benefit from being a reflective practitioner and errors reduced by reflective strategies and their influence on patient outcomes.

2.9 REFERENCES CHAPTER TWO

1. Barrows H, Tamblyn R. Problem-based learning: An approach to medical education. New York: Springer; 1980. Chapter 2, The clinical reasoning process: Problem solving in medicine; p.19-37.

2. Charlin B, Tardif J, Boshuizen H. Scripts and medical diagnostic knowledge: theory and applications for clinical reasoning instruction and research. Academic Medicine 2000; 75:182-190.

3. Fish D, Higgs J. The context for clinical decision making in the 21st century. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p19-31

4. Norman G. Research in clinical reasoning: past history and current trends. Medical Education 2005; 39:418-427.

5. Audétat M, Dory V, Nendaz M, Vanpee D, Pestiaux D, Perron NJ, Charlin B. What is so difficult about managing clinical reasoning difficulties. Medical Education 2012; 46:216-227.

6. Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. Academic Medicine 2003; 78(8):775-780.

7. Norman G, Sherbino J, Dore K, Wood T, Young M, Gaissmaier W, Kreuger S, S Monteiro. The etiology of diagnostic errors: A controlled trial of System 1 versus System 2 reasoning. Academic Medicine 2014; 89:277-284.

8. Zwaan L, Thijs A, Wagner C, van der Waal , Timmermans D. Relating faults in diagnostic reasoning with diagnostic errors and patient harm. Academic Medicine 2012; 87:149-156.

9. Mamede S, Splinter T, van Gog T, Rikers R, Schmidt H. Exploring the role of salient distracting clinical features in the emergence of diagnostic errors and the mechanisms through which reflection counteracts mistakes. BMJ Quality and Safety 2012; 21:295-300.

10. Eva K. What every teacher needs to know about clinical reasoning. Medical Education 2004; 39:98-106.

11. Jerome P. Kassirer. Teaching clinical reasoning: Case-based and coached. Academic Medicine 2010; 85:1118-1124.

12. Mamede S, van Gog T, Sampaio A, de Faria R, Maria J, Schmidt H. How can students diagnostic competence benefit most from practice with clinical cases? The effects of structured reflection on future diagnosis of the same and novel diseases. Academic Medicine 2014; 89:121-27.

13. Reily B. Inconvenient truths about effective clinical teaching. Lancet 2007; 370:705-711.

14. Parsel G, Bligh J. Recent perspectives on clinical reasoning. Medical Education 2001; 35:409-414.

15. Mamede S, Schmidt H, Rikers R. Diagnostic errors and reflective practice in medicine. Journal of Evaluation in Clinical Practice 2007;13:138-145.

16. Mamede S, Schmidt H. The structure of reflective practice in medicine. Medical Education 2004; 38:1302-1308.

17. Mamede S, Schmidt H, Penaforte J. Effects of reflective practice on the accuracy of medical diagnoses. Medical Education 2008; 42:468-475.

18. Mamede S, Schmidt H, Rikers R, Penaforte J, Coelho-Filho J. Influence of perceived difficulty of cases on physicians diagnostic reasoning. Academic Medicine 2008; 83:1210-1216.

19. Mamede S, Schmidt H, Rikers R, Custers E, Splinter T, van Sasse J. Conscious thought beats deliberation without attention in diagnostic decision-making: at least when you are an expert. Psychological Research 2010; 74:586-592.

20. Mamede S, van Gog T, Moura AS, De Faria RM, Peixoto JM, Rikers R, Schmidt H. Reflection as a strategy to foster medical students' acquisition of diagnostic competence. Medical Education 2012; 46:464-472.

21. Ibiapina C, Mamede S, Moura A, Elói-Santos S, van Gog T. Effects of free, cued and modelled reflection on medical students' diagnostic competence. Medical Education 2014; 48:796-805.

22. Chamberland M, Mamede S, St-Onge C, Rivard M, Setrakian J, Lévesque A, Schmidt H, Rikers R. Students self-explanations while solving unfamiliar cases: the role of biomedical knowledge. Medical Education 2013; 47(11):1109-1116.

23. Weiner S, Schwartz A, Weaver F, Goldberg J, Yudkowsky R, Sharma G, Binns-Calvey A, Preyss B, Schapira M, Persell S, Jacobs E, Abrams R. Contextual errors and failures in individualizing patient care: a multicentre study. Annals of Internal Medicine 2010; 153:69-75.

24. Singh H, Giardina T, Meyer A, Forjuoh S, Reis M, Thomas E. Types and origins of diagnostic errors in primary care settings. JAMA Internal Medicine 2013; 173(6):418-425.

25. Graber M. The incidence of diagnostic error in medicine. BMJ Quality and Safety 2013; 22:ii22-ii27.

26. Kaufman D, Yoskowitz N, Patel V. Clinical reasoning and biomedical knowledge: Implications for teaching. In: Higgs J, Jones M, Loftus S, Christensen N. Clinical reasoning in the health professions. 3rd ed. Philadelphia: Elsevier; 2008. p137-151.

27. Boshuizen H, Schmidt H. On the role of biomedical knowledge in clinical reasoning by experts, intermediates and novices. Cognitive Science 1992; 16:153-184.

28. Jones U. The reliability and validity of the Bordage, Grant and Marsden diagnostic thinking inventory for the use with physiotherapists. Medical Teacher 1997; 19(2):133-140.

29. Gehlhar K, Klimke-Jung K, Stosch C, Fischer M. Do different medical curricula influence self-assessed clinical thinking of students? GMS Zeitschrift für Medizinische Ausbildung 2014; 31(2):11-20.

30. Sobral D. Medical students' mind-set for reflective learning: A revalidation study of the reflection-in-learning scale. Advances in Health Science Education 2005; 10(4):303-314.

31. Bordage G, Grant J and Marsden P. Quantitative assessment of diagnostic ability. Medical Education 1990; 24:413-425.

32. Western Cape Government. Groote Schuur Hospital: Overview (Internet). Western Cape Government; 2014 [updated 13 June 2014]. Available from: https://www.westerncape.gov.za/your_gov/163.

33. The College of Medicine of South Africa. Welcome to the college of medicine of South Africa. The College of Medicine of South Africa; 2000-2015 [last updated 2015]. Available from: http://www.collegemedsa.ac.za.

34. HPCSA Health Professions Council of South Africa. 2013 [last updated 2013]. Available from: http://www.hpcsa.co.za.

35. Dewey J. How we think. Boston: Health 1933. Chapter 9, Meaning: or concepts and understanding; p116-134. Available from: http://rci.rutgers.edu/~tripmcc/phil/dewey-hwt-pt1-selections.pdf.

36. Cutrer W, Sullivan W and Fleming A. Educational strategies for improving clinical reasoning. Current Problems in Paediatric and Adolescent Health Care 2013; 43(9):248-257

37. Rifampicin-induced thrombocytopenia. Indian Journal of Pharmacology 2010; 42(4):240-242.

38. Gale J, Maarsden P. Clinical problem solving: the beginning process. Open University, Institute of Educational technology. Medical education 1982; 16:22-26.

39. Sternberg R, Horvath J. A prototype view of expert teaching. Educational Researcher 1995;24:9-17.

APPENDIX A: The Diagnostic Thinking Inventory developed by Bordage, Grant and Marsden [31]

1. (2)	When the patient presents his symptoms,	
	I think of the symptoms in the precise words used by the patient	I think of the symptoms in more abstract terms than the expressions actually used (e.g. '4-day duration' becomes 'acute'; 'two hands' becomes 'bilateral')
2. (3)	In considering each diagnosis	
	I try to evaluate their relative importance	I try to give them equal importance or weighting
3. (5)	In thinking of diagnostic possibilities,	
	I think of diagnostic possibilities early on in the case	First I collect the clinical information and then I think about it
4. (7)	When I am interviewing a patient,	
	I often seem to get one idea stuck in my mind about what might be wrong	I usually find it easy to explore various possible diagnoses
5. (9)	Throughout the interview,	
	If I follow the patient's line of thought, I tend to lose my own thread	I can still keep my own ideas clear even if I follow the patient's line of thought

6. (10) When it comes to making up my mind about a diagnosis,

I do not mind postponing my diagnostic decisions about a case		I feel obliged to go for one diagnosis or another even if I am not very certain

7. (12) Once the patient has clearly presented his symptoms and signs,

I think about them in my mind in the patient's own words		I translate them in my mind into medical terms (e.g. numbness becomes paraesthesia or paralysis)

8. (15) In relation to the routine history

I often feel that I did not sufficiently cover the routine history		I usually cover the routine history to my satisfaction

9. (16) As the patient tells his story and the case unfolds,

I often find it difficult to remember what has been said		I can usually keep track in my mind of what has been said

10. (17) During the course of an interview, I find that

Some key pieces of information seem to leap out at me		It is often difficult to know which items of information to latch on to

11. (18) When I cannot make sense of the patient's symptoms,

I move on and gather new information to trigger new ideas		I ask the patient to define those symptoms more clearly

12. (19) In considering diagnostic possibilities,

I often come up with unlikely diagnoses		I am usually in the right area

13. (20) While I am collecting information about a patient,

The various items of information usually seem to group themselves together in my mind		I often have difficulty seeing how the pieces of information relate to each other

14. (21) When the diagnosis becomes known and I realize that I have missed it initially,

It is often because I knew the disease but failed to think about it		It is often because I did not know enough about the disease

15. (22) During the clinical interview,

I cannot bring myself to dismiss some information as irrelevant		I am quite happy to dismiss some information as irrelevant

16. (23) When I cannot make sense of the patient's symptoms and signs,

I move on to get new information and a new perspective		I look at them from a different perspective before moving on

17. (24) When I consider a number of possible diagnoses,

The diagnoses tend to be related to one another	The diagnoses tend to be scattered

18. (25) When a possible diagnosis comes to my mind,

I usually find myself anticipating possible abnormal signs and symptoms that go with that diagnosis	Quite often, it does not help me to decide what to ask the patient next

19. (26) When I know very little about a particular type of disease,

I can still usually come up with a diagnosis	I have great difficulty in reaching a diagnosis

20. (27) In considering the patient's signs and symptoms,

I think of them each in absolute terms as stated by the patient	I think of them in terms of possible opposites (e.g. progressive *vs* sudden; unilateral *vs* bilateral; spastic *vs* flaccid)

21. (28) When I know a lot about a particular type of disease and have to make a diagnosis,

I find it relatively easy to pin down a diagnosis	I often seem to be all over the place and have difficulty pinning down a diagnosis

22. (29) As the history progresses and I already have some ideas about the possible diagnosis(es),

New information often makes me have more ideas	New information does not often make me have more ideas

23. (31) When I am taking a history, I find that,

I can get new ideas just by going over the existing information in my mind	I need to have new information to make me have a new idea about the case

24. (32) When the patient uses imprecise or ambiguous expressions,

I let him go on to maintain the flow of the interview	I make him clarify precisely what he means before going on

25. (34) After an interview with a patient,

I rarely think of other things that I should have asked in relation to the patient's disorder	I often think of other things that I should have asked in relation to the patient's disorder

26. (35) When a piece of information comes along and makes me think of a possible diagnosis,

It often makes me go back to previous information to see if things fit together or not	It rarely makes me review the information that I gathered previously

27. (36) In relation to the diagnosis I eventually make,

I usually have very few doubts	⎣⎸⎸⎸⎸⎸⎦	I often feel too uncertain for my own comfort

28. (37) In making a diagnostic decision,

I decide by considering each possible diagnosis separately on its own merits	⎣⎸⎸⎸⎸⎸⎦	I decide by comparing and contrasting the various possible diagnoses

29. (40) When I know a lot about a particular type of disease and have to make a diagnosis,

I check up on most possibilities before reaching a decision	⎣⎸⎸⎸⎸⎸⎦	I often have lots of ideas that I don't explore further

30. (41) As the case unfolds,

I do not find it useful to summarize as I go along	⎣⎸⎸⎸⎸⎸⎦	I periodically take stock of the data and my ideas

31. (42) When I reach my diagnostic decisions,

There is often left-over information I have just forgotten about	⎣⎸⎸⎸⎸⎸⎦	I usually will have considered all the information

32. (43) When I have got an idea about what might be wrong with the patient,

I feel most comfortable if I can follow it up without being diverted	⎣⎸⎸⎸⎸⎸⎦	I feel happy to go off on another tack and come back to my original ideas later

33. (44) When I come up with a broad idea as to what might be wrong with the patient,

I can usually proceed to a specific diagnosis	⎣⎸⎸⎸⎸⎸⎦	I find it difficult to put it into specific terms

34. (45) Throughout the interview,

I manage to test my ideas even if I let the patient control the interview	⎣⎸⎸⎸⎸⎸⎦	I am only successful if I can control the direction of the interview

35. (47) In relation to choosing from among the diagnostic ideas that I have,

I am usually not capable of wholly ruling out any of the ideas I have had	⎣⎸⎸⎸⎸⎸⎦	I am capable of ruling out most of my ideas completely

36. (49) Once I have made up my mind about a patient,

I am prepared to change my mind	⎣⎸⎸⎸⎸⎸⎦	I really do not like to change my mind

37. (51) When I consider my diagnostic ideas, I do so on the basis of,

On the case as a whole so far	⎣⎸⎸⎸⎸⎸⎦	A few outstanding symptoms or signs

38. If I do not know what to make of a clinical interview,
(52)

I can readily see the information in new ways	⎣ | | | | | | ⎦	I find it difficult to see the information in new ways

39. When I order laboratory tests,
(53)

I do it as part of the routine clinical investigation	⎣ | | | | | | ⎦	I do it expecting specific information or supporting evidence

40. In considering diagnostic possibilities,
(54)

I compare and contrast the possible diagnoses	⎣ | | | | | | ⎦	I consider each diagnosis separately on its own merits

41. In terms of the way I conduct an interview,
(56)

I usually cover the ground that I need to during the interview	⎣ | | | | | | ⎦	Quite often I do not ask all the questions that I should at the time

NB. Item category identification:

Flexibility in thinking: (21 items)	2, 3, 4, 5, 6, 11, 15, 16, 23, 24, 26, 27, 28, 30, 32, 34, 35, 36, 38, 40, 41.
Evidence for structure in memory: (20 items)	1, 7, 8, 9, 10, 12, 13, 14, 17, 18, 19, 20, 21, 22, 25, 29, 31, 33, 37, 39.

Received 23 *January* 1990; *editorial comments to authors* 16 *March* 1990; *accepted for publication* 15 *May* 1990

APPENDIX B: University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC) Reference: 762/2013

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6338 - **Facsimile** [021] 406 6411
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/research/humanethics/forms

24 January 2014

HREC REF: 762/2013

Prof V Burch
Department of Medicine
J47, Old Main Building

Dear Prof Burch

PROJECT TITLE: THE EFFECTS THAT STRUCTURED RECALL AND ANALYTICAL REFLECTION TAUGHT AT THE BEDSIDE HAVE ON DIAGNOSTIC COMPETENCE

Thank you for your letter to the Faculty of Health Sciences Human Research Ethics Committee dated 24 January 2014.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th January 2015

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/research/humanethics/forms)

We acknowledge that the student Dr Colin Rush is also involved in this study.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC reference no in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

HREC Ref 762/2013

APPENDIX C: Structured Reflection Chart – example for shortness of breath

Analytical Reflection Chart (ARC)

CASE: Shortness of breath   Study number:

STAGE 2 – analytical reflection

Differential diagnosis	+	-	?
1) Asthma	Expiratory wheeze(1)		Atopy (1)
2) COPD		Young patient(1) Non smoker(1)	
3) Diagnostic accuracy		Analytical reflection of illness scripts	

APPENDIX D: Notice of Intention to submit Master's Dissertation for Examination

Faculty of Health Sciences

Notice of Intention to submit Master's Dissertation for Examination

To be completed and returned to : Lorraine McDonald Postgraduate Administrative Officer, Room 2.19 Wernher & Beit Building North, Anzio Rd, Observatory.	**Contact Details :** Tel : (021) 650 7662 Fax : 086 6663224 Email: Lorraine.mcdonald@uct.ac.za
Student Detail: Please print clearly.	
Full Name	Colin Rush
Student Number	RSHCOL002
Degree : eg MSc (Med) in Anatomy	MMed
Minor-Dissertation or Full Dissertation?	
Full Name of Supervisor (Prof/Dr/Mr/Ms)	Prof. Vanessa Burch
Co-Supervisor (1)	-
Co-Supervisor (2)	-
Dissertation Title : **Please print clearly**	**The effect of structured reflection on the diagnostic accuracy of postgraduate trainees during real patient encounters**
Submission for possible graduation in June or December?	
Submit: 2 temporarily bound copies plus a CD in a universally readable format (preferably pdf format).	
Submit: An **Abstract** of your work, not exceeding 1page.	
Remember that a signed and dated **Declaration** must be included and inserted in the front of your dissertation.	
Have you submitted a **Study Proposal**?	NO
Have you **registered** this year?	YES

Contact details during examination and graduation process:

Postal Address	4b Albion Mews, No. 1 Albion Road, Rondebosch, Cape Town 7708
Telephone (H) Telephone (W)	021 685 1341 072 904 8976
Fax Number	-
Email Address	Rshcol002@gmail.com

PLEASE NOTE: If you submit your dissertation for examination at a time other than the faculty submission dates of 15 March and 15 August, there may be a considerable delay before receiving your examination results. While every effort will be made to process the work for examination as soon as possible the faculty does not however undertake to reach a decision on the award of the degree by any specific date.

I undertake to inform the Manager: Postgraduate Administration ***immediately*** should I not be able to meet the deadline for submission, i.e. 15 March or 15 August.

Signature: ______________________ **Date:** ______________________

APPENDIX E: Approval of Study Proposal

University of Cape Town

Faculty of Health Sciences

Form D1: Approval of Study proposal

SUBMISSION OF STUDY PROPOSAL FOR A MASTER'S OR DOCTORAL DEGREE *AFTER ETHICAL APPROVAL*

PLEASE NOTE: This form must not be sent to Ethics

I would like to submit the following proposal and supporting documentation for consideration by the Dissertations Committee (after Ethics approval).
Signature (Candidate): ____________________

NAME OF CANDIDATE	Colin Rush
STUDENT NUMBER	Rshcol002 1265920
QUALIFICATIONS	MBCHB (UCT)
TITLE OF PROPOSED PROJECT **(Proposal attached)**	**The effects that structured recall and analytical reflection taught at the bedside have on diagnostic competence.**
DEPARTMENT	Internal Medicine
LEVEL OF PROJECT – Master's or Doctoral	Master's
PROPOSAL SUPPORTED BY DEPARTMENTAL RESEARCH COMMITTEE	Name of Chair, Department Research Committee: **Signature:**
PROPOSAL APPROVED BY (Delete any one if not applicable)* Human Ethics Committee, ERC No:	***(Attach Ethics approval letter)***
FINAL SUBMISSION APPROVED BY SUPERVISOR	Supervisor Name: PROF. V BURCH Signature:
NAME(S) OF CO-SUPERVISOR(S)	1. - (Staff No:) 2. (Staff No:) 3. (Staff No:)

APPENDIX F: Supervisor appointment form

University of Cape Town

Faculty of Health Sciences

Form D3: Supervisor Appointment form

Name and student no of proposed candidate:	Colin Rush	Rshcol002
Degree name (e.g. MSc(Med) in Physiology)	MMed.	

Name of Supervisor/co-supervisor	Prof. Vanessa Burch
UCT staff number	
UCT Academic Department	Department of internal medicine
Division	General Medicine
Permanent or contract staff? If contract, when did your contract start and when will it end?	Permanent staff
Educational Qualifications	MBBCh, MMed, PhD
Are you registered with a Professional Council in SA?	Yes
If yes, in what category?	Medical practioner
Please provide Council/Professional body registration number	MP332160
Have you previously supervised a candidate at this level?	Yes
How many students are you currently supervising/co-supervising?	5
If yes, how many and at what level?	PG Diploma:- Honours:- Master's: 2 Doctoral: 3
If none, then please provide a brief motivation for doing so now. *HOD please state the arrangements for mentoring of the novice supervisor*	-
Have you previously submitted a CV or resume to the postgraduate office? If not, then please attach a recent CV or resume	Please find CV attached

Supervisor/co-supervisor signature: ____________________ Date: ________________

I approve/ do not approve the appointment of the above-named supervisor/co-supervisor

HOD name: ________________________________

HOD signature: ____________________________ Date: ________________

I approve/ do not approve the appointment of the above-named supervisor/co-supervisor

Deputy Dean: Postgraduate Affairs

Signature: ________________________ Date: ________________

Form D3 - 2007

APPENDIX G: Author Instructions

Journal for publication: Medical Education (http://www.mededuc.com)

Original Research Guidelines

'***Original Research***: Generally less than 3,000 words, but longer papers will be accepted if the context warrants the inclusion of more text (see Med Educ 2010; 44:432). An abstract, structured under subheadings, of no more than 300 words must be included and the paper should contain a maximum of five tables or figures with references included in the Vancouver style.'

Literature Review

Word Count: 3902

Figures: 2

Tables: 0

Referencing: Vancouver style

Manuscript 1

Word Count: 3512

Figures: 4

Tables: 3

Referencing: Vancouver style